Classification of lie and truth in forced choice paradigm: an fNIRS study

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Introduction:

Accurate and reliable detection of lie or deception is an interesting challenge for experts in many scientific areas. Polygraph is widely used for lie detection (Farwell and Donchin 1991), which uses an indirect method that measures several physiological indices of anxiety like heart pulse rate, respiration, blood pressure, and skin conductance. Based on the hypothesis that, it might be possible to understand and ultimately detect deception if we can directly look at the brain function, a number of researchers have recently investigated different neurophysiological signals for possible application of lie detection, including fMRI, EEG and fNIRS (Langleben at al. 2005, Rosenfeld et al. 2012, Hu et al. 2012). fNIRS provides a better trade-off between temporal and spatial resolutions as compared to EEG and fMRI (Naseer and Hong 2013, Kamran and Hong 2013, Santosa et al. 2013). In this study, we have classified lie and truth based on the signals acquired by fNIRS in a forced choice paradigm. Results show that the difference in oxy and deoxy-hemoglobin (HbO and HbR) signals during lie and truth can be detected by fNIRS.

Methods:

Four healthy male subjects (mean age 28.5 ± 3.13) participated in the experiment. Concealed information test (CIT) is a method of interrogation that uses crime details known only to the criminal involved in the crime (Rosenfeld et al. 2012). We used a modified CIT of the previously reported guilty knowledge test (GKT) (Langleben at al. 2005) as our experimental paradigm. A sequence of playing cards was presented on a computer screen with random cards, while each sequence is composed of five stimuli as shown in Fig. 1. Control and neutral cards were shown only to keep the subject active. Numbered cards were presented for 2 s followed by a 10 s of null during which the back of card was displayed. All cards were shown once in a sequence except the control cards which was shown twice. Subjects were instructed to press a left key for yes and the right key no on a keyboard. A total of 10 sequences were presented with a total session length of 10 mins. The experimental paradigm is shown in Fig. 1. Subjects were presented two envelops, one containing 2 of heart and other 5 of spades. Subjects could choose one envelop and keep the identity hidden from the administrator. The administrator instructed subjects to deny possession of the card they had with them. Subjects were asked not to tell a lie other than the card they had with them.
A new wireless fNIRS machine (Bhutta and Hong 2013) was used at a sampling rate of 10 Hz. The optode configuration and channel distribution is shown in Fig. 2(a). Position of optical probe is shown in Fig. 2(b). Modified Beer-Lambert law is used to convert the intensity of incident and detected light into concentration changes in HbO and HbR. The measured data is high-pass filtered at cut-off frequency of 1.5 Hz to remove the physiological noise. Linear discriminant analysis (LDA) was used for classification of lie and truth. Classification is performed on the average signals of HbO and HbR for the true and lie portion of the sequence.

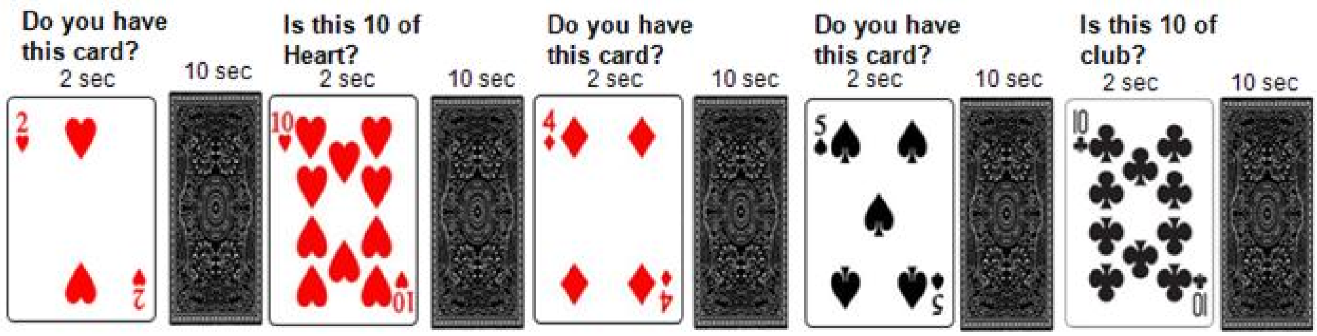


Fig. 1. A single sequence of experimental paradigm. Five stimuli in each sequence: (1) Lie (2 of hearts or 5 of spades); (2) Truth (2 of hearts or 5 of spades); (3) Control (10 of club and 10 of hearts); (4) Neutral (4 of diamond); and (5) Null (back of card)

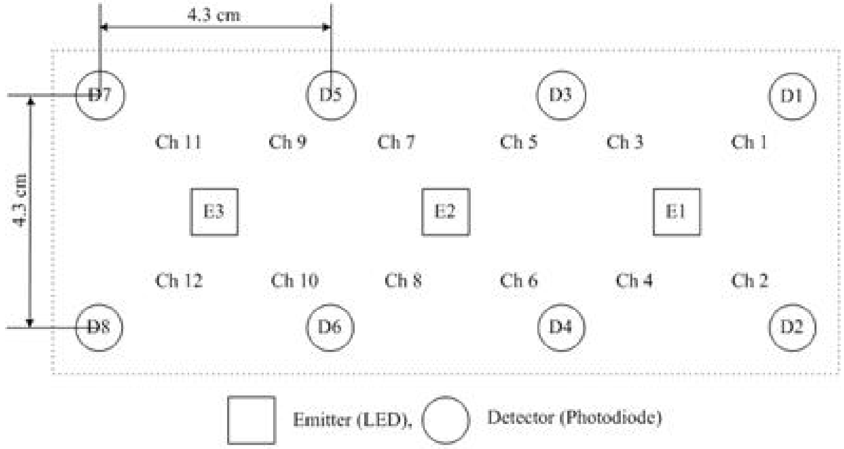


Fig. 2(a). Optode configuration and channel distribution

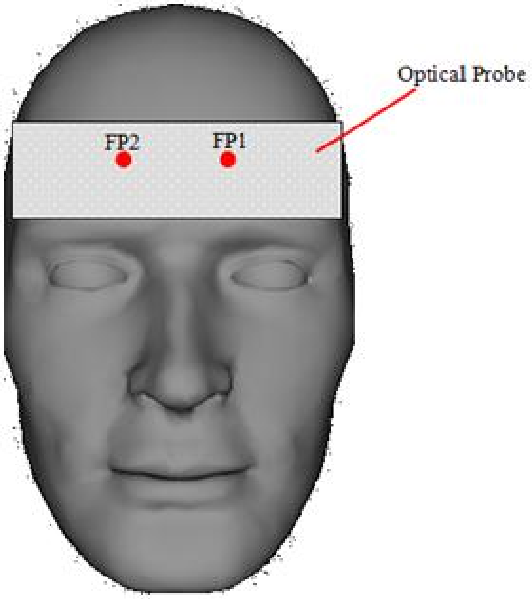


Fig. 2(b). Position of optical probe on subject forehead

Results:

The classification accuracy is based on the number of correct classifications over the total number of classifications for each channel. Two different classes (true and lie) obtained are shown in Fig. 3. The red circles represent the lie and blue crosses represent the truth. The classification accuracy of all channels for each subject is presented in Fig. 4.

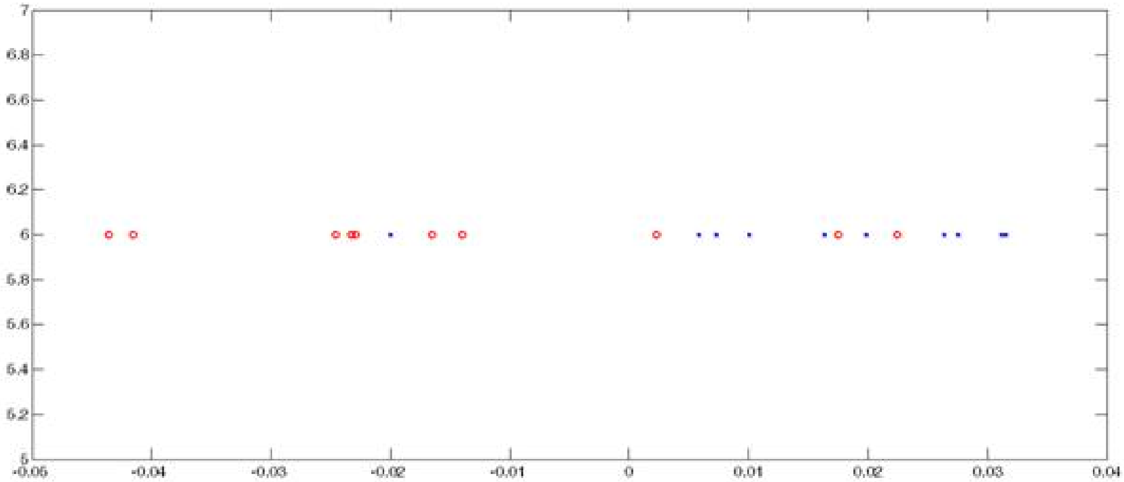
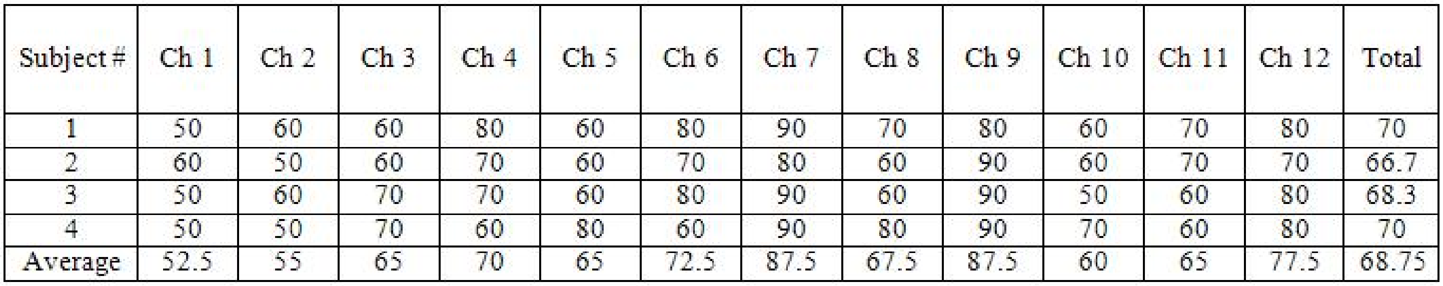


Fig. 3. Classification of lie and truth for channel 9 of subject 2



Subject #	Ch 1	Ch 2	Ch 3	Ch 4	Ch 5	Ch 6	Ch 7	Ch 8	Ch 9	Ch 10	Ch 11	Ch 12	Total
1	50	60	60	80	60	80	90	70	80	60	70	80	70
2	60	50	60	70	60	70	80	60	90	60	70	70	66.7
3	50	60	70	70	60	80	90	60	90	50	60	80	68.3
4	50	50	70	60	80	60	90	80	90	70	60	80	70
Average	52.5	55	65	70	65	72.5	87.5	67.5	87.5	60	65	77.5	68.75

Fig. 4. % of classification accuracies of all channels for all four subjects.

Conclusions:

In the setting of forced choice paradigm, the concentration change of HbO and HbR is different during lie and truth. In this study, we have classified lie and truth based on the concentration change of HbO and HbR signals obtained by a multichannel fNIRS system. The high classification accuracies achieved at active channels under the present paradigm confirms the feasibility of a practical fNIRS based lie-detection system.

Imaging Methods:

Optical Imaging/NIRS

Reference

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